Implementation of U.S. Customary Units In Statewide CADD Applications

1. General

The Department has two main Computer Aided Drafting & Design (CADD) software applications: CAiCE and MicroStation. CAiCE (Computer Aided Civil Engineering) is the Department's roadway design and digital terrain modeling (dtm) software. MicroStation is the Department's drafting software, which is the file format for all PS&E submittals.

ArcGIS is available throughout the Department for Engineering GIS applications. The ArcGIS software is used during the preliminary design phase to assist engineers with Project Study Reports and Hydrology studies. The need to transfer electronic information between ArcGIS and (CAiCE and MicroStation) is increasing.

2. CAiCE

Highway design units throughout The Department use the CAiCE software statewide to develop horizontal alignments, design profiles, earthwork volumes, superelevation diagrams, design cross sections and slope stake notes. The Office of Photogrammetry and District Survey units use CAiCE to create the digital terrain models (dtms) for topographic mapping. CAiCE software can operate in either metric or U.S. customary mode, but needs certain customized resource files before it can be used for design. An update to the CAiCE software to provide design engineers with the U.S. customary parameter files will be released in spring 2005.

CAiCE Highway Design has nine training manuals to update. CADD staff will attempt to update these manuals by June 2006 so that design staff can begin working in U.S. customary units.

3. G.I.S.

ArcGIS is used in the preliminary design phase of projects. It is used in conjunction with WMS for offsite hydrology studies. The mapping is currently in a format called a shapefile. This mapping will have to be converted to U.S. customary units. ArcGIS and WMS use Digital Elevation Models in both 30 meter and 10 meter cell sizes. This data can also be converted to a Triangular Irregular Network (TIN) format and combined with a TIN from CAiCE when doing Hydrology studies. The ArcGIS/WMS Hydrology manual, shape files, and DEMs should be converted to U.S. customary units by spring 2005.

ArcGIS is capable of projecting a variety of coordinate systems on-the-fly so that GIS mapping in multiple projections can overlay each other correctly. The problem is GIS mapping will only export into MicroStation or CAiCE in its native coordinate system. GIS mapping will need to be changed to units of feet instead of meters before exporting.

4. MicroStation

MicroStation has been the Department's drafting software for more than ten years. All the final contract plans are required to be submitted in the MicroStation file format (dgn). Standard Plans and detail sheets are developed using MicroStation. Preliminary drawings and strip maps use MicroStation to combine vector data with aerial photography for preliminary documents and public hearings.

The MicroStation support team has developed a standard cell library, line style resource file, font resource file and seed files for engineers and consultants to use. These resource files allow the designer to quickly use the standard Caltrans symbology and features for complete, accurate, and consistent plans.

The Department has begun the task of looking at the latest version of MicroStation, which is version 8 (V8). V8 can handle the use of existing metric files referenced to any U.S. customary unit files easier than version 7 can. The estimated release date of MicroStation V8 is June 2006.

MicroStation software does not have a problem handling either a metric or U.S. customary project, as long as the appropriate resource files are available. In order for designers to begin the project development process in U.S. customary units, the MicroStation support team will convert the required resource files by spring 2005.

Interim Computer Aided Drafting & Design Standards for U.S. Customary Units (English) Plans

1. Plan Sheet stationing shall be based on 100-feet per station with full annotation at 500-foot stations (multiple of 5). Annotation at 100-foot stations is a single digit number (the ones column). Station annotation shall not include plus stations (i.e. +00).

   Example of stationing:

   …….9, 260, 1, 2, 3, 4, 265, 6, 7, 8, 9, 270, 1, ……..

   Stationing for Preliminary Drawings shall also be based on 100-feet per station and with full annotation at 500-foot stations for both: 1" = 200' and 1" = 400'. The 100-foot stations do not need to be annotated.

   Stationing for identifying begin and end limits regarding items of work and offsets shall be shown to the hundredth of a foot.

   The typical length of a station tick mark (in a MicroStation design file) is 2.8 feet at 1" = 20', 7.0 feet at 1" = 50' and 14.0 feet at 1" = 100'. Station tick marks are centered on the alignment line. Annotation is placed below the alignment line.

2. Scales:

	English		Metric
Detail Sheets:			
	1/8"=1'		1:100
	3/16"=1'		1:50
	1/4"=1'		1:50
	3/8"=1'		1:50
	1/2"=1'		1:20
	3/4"=1'		1:20
	1" = 1'		1:10
	1" = 2'		1:20
	1" = 5'		1:50
	1" = 10'		1:100
Plan Sheets:			
	1" =20'		1:200
	1" =50'	(**base scale**)	1:500
	1" =100'		1:1000
Preliminary Drawings:			
	1" =200'		1:2000
	1" =400'		1:5000

Profile Sheets:

Vertical to horizontal scale ratios producing profile grade line plots steeper than 1:1 should be avoided. Scale ratio of H/V = 10 is most commonly used.

The following scales are appropriate for the conditions described:

Type of Conditions	English		Metric	
	Horizontal	Vertical	Horizontal	Vertical
Rural sections in hilly or mountainous terrain	1" = 100'	1" = 10'	1:1000	1:100
Rural or Urban with gentle rolling terrain	1" = 50'	1" = 5'	1:500	1:50
Rural or Urban with level terrain	1" = 20'	1" = 2'	1:200	1:20

Cross Sections:

Cross section intervals shall not be greater than 50 feet. More frequent intervals should be provided when changing roadway conditions aren't adequately shown using 50-foot intervals. More frequent intervals are also necessary (particularly for use by Surveys) when the profile grade approaches or is less than the minimum grade of 0.3%.

The horizontal (H) and vertical (V) scales should be the same. Cross sections using the same H/V scale allows either hard copy or electronic cross sections to be utilized in determining earthwork quantities. Maintain the same scale for all cross sections for one alignment.

Earthwork cross section plotting scales are:

	English	Metric
Rural	1" = 10'	1:100
Urban	1" = 5'	1:50

3. Contour Intervals:

For U.S. customary units, the index contour line will be every fifth contour and will be a heavier weight than the intermediate contour lines. In metric units, the index contour lines were every fourth contour when using 1:200 & 1:500 scales.

In very steep terrain (at any scale), the intermediate contours may be eliminated if the contour lines are so close together affecting the readability of the mapping or plans.

English			Metric		
	Contours			Contours	
Scale	Index	Intermediate	Scale	Index	Intermediate
1” = 20’	5 ft	1 ft	1:200	1 m	0.25 m
1” = 50’	10 ft	2 ft	1:500	2 m	0.5 m
1” = 100’	20 ft	4 ft	1:1000	5 m	1 m
1” = 200’	50 ft	10 ft	1:2000	10 m	2 m
1” = 400’	100 ft	20 ft	1:5000	25 m	5 m

4. Pavement cross slope and superelevation shall continue to be shown as percent.

5. Angular measurement will retain the Degree-Minute-Second convention.

6. Dual units shall not be allowed on any Contract Plans. All survey information will be expressed in english units.

7 Side slopes shall be expressed in a non-dimensional ratio. The horizontal component shall always be shown first and then the vertical component (X:Y). When a side slope becomes steeper than 1:1, the horizontal component shall be shown as a fraction (3/4:1).

Interim CADD Standards for U.S. Customary Units (English)

1. Text sizes for developing Highway Projects in English.

	ENGLISH			METRIC
DESCRIPTION	**SIZE ***	**FONT**	**WEIGHT**	**EQUIV.**
Title Project Description	TX = 14.5	43	0	3.7 m
Name and ID Code of Individual Plan Sheets, (does not apply to the Title Sheet.	TX = 14.5 **	43	0	3.7 m
Titles for Quantity Tables and Detail Drawings	TX = 12	43	0	3.0 m
Country and State boundary	TX = 11	43	0	2.8 m
City Names on the Title Sheet Strip Map	TX = 10	43	0	2.5 m
Begin and End Work on Title Sheet. Titles for Informational Tables	TX = 10	3	2	2.5 m
Subtitles for Tables and Detail Drawings. Route and Route No. Headings in Quantity of Summary	TH = 8.75 TW = 8.75 ***	3	2	2.2 m 2.2 m
River Names (Water Ways)	TX = 7	3 ****	1	1.8 m
Majority of Text, (including text with drawings, tables and dimensioning	TX = 7	3	1	1.8 m
Restricted Space for Placement of Text	TH = 7 TW = 6	3	0	1.8 m 1.5 m
Photogrammetric Mapping Text	TX = 6	2	1	1.5 m

* TX = represents height (TH) and width (TW) in **feet** for Caltrans standard 1" = 50' drawings.

** Adjustable if necessary (TX = 12 minimum).

*** Reduce text width (TW = 7 minimum), if needed for restricted space.

**** Do not use Font 23. It is obsolete and does not have the appropriate spacing for characters or the desired appearance for certain letters. Use Caltrans standard Font 3 (CTfont1) with a slant angle of 25 degrees instead.

Option: If a plan sheet has multiple routes and is a busy and cluttered sheet, making it difficult to see the route labeling, then the Route and Route No. may be placed using a text size of (TX = 10, Font = 43, WT = 0) if space allows.

2. Text Size – Right of Way (R/W) Mapping Products

In the Caltrans CADD system, all R/W drawings are created at one "Design Plane" size of 429,496 squared feet. Maps are developed at a ratio of 1 to 1, but can be plotted at any desired scale. Text sizes were determined based on how the text looked within the border sheet and what information should be shown more prominently. The size for the text listed in the table below, is based on a plotting scale of 1” = 50’ (Caltrans Base Scale). It is important to place text at the appropriate CADD size within the drawing based on the intended scale of the plotted plan sheet.

Right of Way uses several fonts that are specific for their use only. These specific fonts are 4 (CTFONT-RW), 7 (Adline), 55 (Fancy–Old Mon. Font2) & 56 (Shadow).

	ENGLISH			METRIC
DESCRIPTION	**SIZE ***	**FONT**	**WEIGHT**	**EQUIV.**
Predominantly Numeric Annotation including bearings & distances, curve data, coordinates, and stationing.	TX = 5.0	3	1	TX = 1.25
Detail Labels (i.e. DETAIL "A" & SEE DETAIL "A")	TX = 10.0	3	3	TX = 2.5
"NO SCALE" label	TX = 5.0	3	2	TX = 1.25
Descriptive Annotation including easement descriptions, "EXISTING R/W", "CITY LIMITS"	TX = 5.0	4	1	TX = 1.25
Route Label along alignment	TX = 7.0	4	2	TX = 1.75
Map Sheet Reference Label (i.e. "SEE MAP 81328")	TX = 8.0	4	2	TX = 2.0
Lot/Block/Parcel Labeling Large (i.e. BLOCK 9) Medium (i.e. LOT 2)	 TX = 12.0 TX = 10.0	4	 1 1	 TX = 3.0 TX = 2.5
County and City Labels	TX = 26.0	7	2	TX = 6.5
Government Landnet Labeling Township & Range Large (i.e. SECTION 1) Medium (i.e. GOVT TRACT 21) Small (i.e. GOVT LOT 3)	 TX = 14.0 TX = 12.0 TX = 10.0 TX = 8.0	55	 3 1 1 1	 TX = 3.5 TX = 3.0 TX = 2.5 TX = 2.0
Subdivision & Record Map Labeling Large (i.e. ROS 6-8) Medium (i.e. PM 2-3) Small (i.e. OR 7-11)	 TX = 14.0 TX = 12.0 TX = 10.0	56	 2 2 2	 TX = 3.5 TX = 3.0 TX = 2.5

* TX = represents height (TH) and width (TW) in feet for Caltrans standard 1" = 50' drawings.

3. Text Size – for developing Structures projects in English.

The working units for Structures text are **Master Units**: feet, **Sub Units**: inches. For the base-working units (1" = 1'-0"), the resolution is 12 inches per foot and 8000 positional units per inch for a working area of 44,739 squared feet.

DESCRIPTION	SIZE	FONT	WEIGHT
Informational notes - majority of plan lettering requirements and border information	0.1200	3	1 or 2
Detail Titles	0.2400	3	4
Detail Titles	0.2400	43	0
Sheet Titles and Border information	0.2400	43	0

Size of font (both height and width) is in feet for the base-working unit of (1" = 1'-0").

As the positional units are changed to accommodate a different scale, the size of the text will change automatically. The table below shows the proper size of text for each scale in feet.

Text sizes at various scales

U.S. Customary Units (English)	Inch Per foot	Positional Units	Text Size
1’ = 1’-0” (full-size)	12	96,000	0.0100
6” = 1’-0” (half-size)	12	48,000	0.0200
3” = 1’-0”	12	24,000	0.0400
1 1/2” = 1’-0”	12	12,000	0.0800
1” = 1’-0”	**12**	**8000**	**0.1200**
3/4" = 1’-0”	12	6000	0.1600
1/2“ = 1’-0”	12	4000	0.2400
3/8” = 1’-0”	12	3000	0.3200
1/4" = 1’-0”	12	2000	0.4800
3/16” = 1’-0”	12	1500	0.6400
1/8” = 1’-0”	12	1000	0.9600
3/32” = 1’-0”	12	750	1.2800
1” = 10’	12	800	1.2000
1” = 20’	12	400	2.4000
1” = 40’	12	200	4.8000
1” = 50’	12	160	6.0000
1” = 80’	12	100	9.6000
1” = 100’	12	80	12.0000
1” = 200’	12	40	24.0000
1” = 250’	12	32	30.0000
1” = 400’	12	20	48.0000
1” = 500’	12	16	60.0000
1” = 1000’	12	8	120.000

NOTE: The text size shown in the table above is for Informational notes.

4. Units of Resolution for Highway Construction

There is only ONE setting for any CADD prepared Highway Construction project (also includes Highway Planting projects), and it shall be:

Master Units (MU)---------- feet
Sub Units (SU) ---------- 10 (tenths per foot)
Positional Units (PU) ----- 1000 (Pos. Units per sub unit)
Working Area ---------- 429,496 (squared feet)

The above setting has 1000 positional units between each tenth. This is the only setting for Highway Construction projects and it should never be changed. If the number of positional units was inadvertently increased (more positional units per tenths), the working area (design plane size) would become smaller and the coordinate value of a given precise point would become a different value. The accuracy of measuring and dimensioning would improve, but that is not how Highway Construction projects are handled at Caltrans.

5. Units of Resolution for Structures

Structures will draw to a particular scale by changing the positional units. Changing the positional units allows the user to draw a second detail at a different desired scale within one design file (plan sheet). Changing the positional units will alter the coordinate value of a given precise point in the design file. For Structures, the base-working unit in U.S. customary units (english) is (1" = 1'-0"). The following are the values that determine the base-working unit:

Master Units (MU)---------- feet
Sub Units (SU) ---------- 12 (inches per foot)
Positional Units (PU) ----- 8000 (Pos. Units per sub unit)
Working Area ---------- 44,739 (squared feet)

The table below shows the english scales that Structures uses. By changing the Positional Units (3rd column) the desired english scale is achieved (1st column). The Working Area (4th column) will change automatically with the change in Positional Units.

English Scales and Working Area determined by the Changing of Positional Units

U.S. Customary Units (English)	Inches Per Feet	Positional Units	Working Area (squared feet)
1’ = 1’-0” (full-size)	12	96,000	3728
6” = 1’-0” (half-size)	12	48,000	7456
3” = 1’-0”	12	24,000	14,913
1 1/2” = 1’-0”	12	12,000	29,826
1” = 1’-0”	**12**	**8000**	**44,739**
3/4" = 1’-0”	12	6000	59,652
1/2“ = 1’-0”	12	4000	89,478
3/8” = 1’-0”	12	3000	119,304
1/4" = 1’-0”	12	2000	178,956
3/16” = 1’-0”	12	1500	238,609
1/8” = 1’-0”	12	1000	357,913
3/32” = 1’-0”	12	750	477,218
1” = 10’	12	800	447,392
1” = 20’	12	400	894,784
1” = 40’	12	200	1,789,569
1” = 50’	12	160	2,236,962
1” = 80’	12	100	3,579,139
1” = 100’	12	80	4,473,924
1” = 200’	12	40	8,947,848
1” = 250’	12	32	11,184,810
1” = 400’	12	20	17,895,697
1” = 500’	12	16	22,369,621
1” = 1000’	12	8	44,739,242